27 Central Emergency Power Stations (CEPS), Central Power Stations (CPS) and Central Energy Plant (CEP)

27.1 Background
This policy defines the technical and operating requirements for centralised power generating plant including:

a) Central Emergency Power Stations (CEPSs);
b) Central Power Stations (CPSs)
c) Central Energy Plants (CEPs)

This policy includes requirements for:

a) Power station building layouts;
b) Generating sets;
c) Mechanical auxiliary systems;
d) Electrical auxiliary systems;
e) Control system hardware and software;
f) Communications Networks, and
g) Operating Philosophy.

This policy provides guidance and detailed technical material as necessary to define the Defence performance requirements and standards to be applied, in addition to the applicable statutory regulations and standards.

The content of reference standards, regulations and other publications, have not been repeated in this publication unless necessary for descriptive purposes. Where necessary and appropriate, reference is made to the source of the information.

When required, Defence establishments are provided with either one of two types of power station:

**Central Emergency Power Station** - is a standby power station provided where there is a requirement to supply power to the Base in the event of loss of the mains power supply. This generally is a requirement at establishments where important functions are performed, an example being aircraft operations as these are highly dependent upon power to ensure the continued operation of the airfield and supporting facilities.

**Central Power Station** - is a prime power station provided where mains supply is unavailable.

**Central Energy Plant** – is a power station that is used primarily to offset power purchases from the grid. It might also have cogeneration facilities to utilise waste heat.
The power station systems, either CEPS or CPS, need to maintain a high level of autonomy and reliability in the provision of electrical supply.

The CEPS/CPS works in close coordination with load shedding controls under the Defence Engineering Services Network (DESN) Power Control and Monitoring System (PCMS) module in order to ensure that the total Base load does not exceed the available generating capacity.

27.2 Performance Objective
The objective of this policy is to:

a) Facilitate fully automated power generation systems, albeit with routine operator intervention to safeguard the system;
b) Provide a consistent operator interface for operators;
c) Provide facilities that are fully compliant with NSP requirements;
d) Safeguard high voltage systems operating activities;
e) Ensure the economics of the design on a through life basis;
f) Minimise the impact of single points of failure; and
g) Facilitate energy management and greenhouse gas reductions.

27.3 Referenced Documents

Standards/Codes
All materials and workmanship shall be of the best standard and shall comply with the relevant Australian Standards, or if such do not exist, with the relevant IEC or International (ISO) Standards.

Irrespective of any requirements shown in these documents the installation as a whole shall comply with:

Australian Standards

AS 60529    Degrees of Protection Provided by Enclosures.
AS 2381     Electrical Equipment for Explosive Atmospheres. (Series)
AS/NZS 3000  Wiring Rules.
AS 3702     Item Designation in Electrotechnology.
AS 3013     Electrical Installations – Wiring Systems for Specific Applications.
AS/NZS 3010  Electrical Installations – Generating Sets
AS 4070     Recommended Practices for protection of low voltage electrical installations and equipment in MEN systems from transient voltages.
27.4 Power Station Building Requirements

27.4.1 Site Selection
The site for the power station should be in general conformance with the area identified in the site electrical master plan. Detailed site selection within the master planned area needs to be considered. If there is no master planned site selected, the designer shall propose a site in the Concept Design Report. In evaluating sites the Designer shall consider the planning/design site selection and electrical criteria identified in this MIEE.

The final location must be agreed by DEEP as part of the design report process. Final ratification of a site is dependent upon local site approval procedures, such as site selection boards.

27.4.2 Site Access
The requirements for access, including those for entry and also exits and escape, shall be considered in the design.

Particular attention shall be given to allowances for vehicular access. This includes access for:

a) Construction activities for construction plant and equipment. Vehicles shall be assumed to be of the large flat bed truck types;

b) Fuel deliveries.

27.4.3 Physical Arrangement
Construction
Generating plant, switchboards and controls shall generally be located indoors within purpose built power station buildings. The use of freestanding outdoor generator enclosures can be considered but is subject to approval by DEEP. The materials from which the power station building is constructed, both internally and externally, shall be durable and suitable for long-term use without excessive maintenance.

Other Standards
The rules and regulations of the relevant NSP.

The Building Code of Australia (BCA).

IEC 61131-3  Programmable Controllers – Programming Languages

The requirements of any other Authority having jurisdiction over the installation.
Segregation of Equipment

Major items of plant shall be physically segregated within the building to minimise the potential for a single event to disable the entire station. The preferred arrangement includes the following individual spaces that have substantial physical and 2 hour fire rated barriers between them:

a) Two generating halls;
b) Two bulk fuel tank rooms, one associated with each generating hall (where the bulk fuel storage is located within the building);
c) Separate day fuel tank rooms for each hall (if required to address hazardous area considerations);
d) Two HV electrical switch rooms, one associated with each generating hall, with direct access from the control room where possible, and
e) A single control room.

Where there are no equivalent dedicated facilities accessible in the vicinity of the CEPS installation, the following additional rooms shall also be provided:

a) A workshop incorporating appropriate space for CEPS spares holdings, and
b) Lubricating oil store.

Amenities

The power station building shall include a Control Room, equipped as outlined in below.

Where the power station operates as a CPS or CEP installation, the following additional amenities shall be included:

a) Toilet facilities;
b) A sink with boiling water unit;
c) A shower.

Other facilities as required may be included subject to DEEP approval.

Visual Monitoring

Where possible the Control Room shall share common walls with the generating halls. Small fire and acoustic rated windows should be included in these walls to allow the operators to visually monitor the generating plant.

Containerised Arrangement

Enclosures for containerised generating sets shall include the following additional features:

a) The enclosure shall be trafficable so that an operator can walk around at least three sides of the generating set, within the enclosure.
b) Safety clearances shall be adequate so that an operator can safety enter the enclosure and access the generating sets while it is running.
c) The enclosure shall be adequately sound treated for the location in which it is installed.
d) The enclosure shall be equipped with the following services:

e) At least two power outlets, one on each side of the set;

f) Self contained emergency lighting;

g) A permanent monorail hoist to allow heavy components to be lifted and items of plant to lifted and placed safely.

**Equipment Layout**
The layout of the power station shall consider the following issues:

a) The equipment layout shall provide adequate access for operation with all controls placed for ready access and with all indicators and instrumentation in easy to read locations. Station controls shall be in a single room unless formally agreed by DEEP.

b) In the design of the equipment layout, adequate access for the installation and erection of the equipment shall be provided.

c) Major equipment items shall not be located in such a manner that would prevent the safe removal and replacement of any other major item of the installation.

**Noise**
The design of the power station shall limit the impact of noise on adjacent habitable spaces to acceptable levels. This should include suitable construction materials and the orientation of openings in the structure through which noise can escape.

Potential sources of noise emission include:

a) Exhaust stacks;

b) Radiators;

c) Ventilation and other mechanical plant;

d) Transformers, and

e) Direct emission from the engine.

This includes plant that is located within the building that can escape the building through ventilation openings or the building structure.

The design should also consider the transmission of noise within the building, particularly to spaces that are normally occupied, such as the Control Room.

**Services**

**Electrical**
Adequate power outlets shall be provided to facilitate the maintenance of equipment. In addition to general power outlets this should include future needs for welding and oil filtration equipment for large transformers.
Electrical lighting within the operational spaces shall be connected to a UPS that provides at least 4 hours of operation with all lights running. In addition single-point emergency and exit lighting shall be provided connected directly to the mains supply.

**Mechanical**
The Control Room and Switch rooms shall be air-conditioned. This shall be achieved using at least two AC units to achieve redundancy. 100% redundancy is not required, e.g. when two AC units are installed each should be sized to approximately 70% of the AC load.

**Communications**
The Control Room shall be provided with a telephone connected to the site telephone system.

**Defence Engineering Services Network (DESN) Provisions**
The Control Room is generally a major node of the DESN. The following facilities shall be provided within the Control Room to allow for the DESN:

a) A office desk suitable for:
   - A PC and 21 inch screen;
   - Two inkjet printers.

b) An office chair;

c) Space for a 19 inch server rack (also to house the system UPS);

d) Space for a 19 inch communications rack;

e) Communications ducting from the Communications Rack location to:
   - Outside the building (100 mm dia) for installation of fibre optic cabling from outside the building;
   - To each PC and printer location.

f) Power ducting (25 mm dia) from the Server Rack location for future installation of UPS cabling to power outlets at:
   - At the PC;
   - At each printer;
   - The Communications Rack.

g) Power ducting (32 mm dia) from each DC switchboard to:
   - The Server Rack;
   - The Communications Rack.

h) Power ducting (25 mm dia) from the AC switchboard to:
   - The Server Rack;
   - The Communications Rack.
**Electrical Isolation**
If the power station is connected to the site HV distribution system it will be a major substation on that system. Care should be exercised in the design of any external; services connections to minimise the possibility of transferring dangerous electrical potentials outside the station. This particularly includes adjacent metallic fences, and external pipe and electrical connections.

In general all pipe connections to the building should be non-conductive. Communications connections should be made through isolating transformers or be fibre optic.

**Passive Defence**
Passive defence requirements as identified in the Threat Assessment shall be considered in the design. As a minimum this should include:

a) Location of fuel tanks underground or in other protected locations, with filling points located to minimise tampering;

b) Location of external equipment out of direct line of sight from boundary fences or the provision of suitable physical protection from ballistic attack;

c) Location of openings in the structure considering lines of sight from boundary fences; and

d) Suitability to deal with ground shock and vibration isolation.

At northern bases passive defence normally includes protection against man portable weapons. In general terms this requires an earth covered structure. Such a structure poses a number of technical challenges, not the least of which is getting cooling air through the building while maintaining adequate levels of weapons protection. In addition target identification needs to be considered, particularly the thermal plume created by the power station. Suitable measures to reduce the temperature of the plume are atempering systems such as water sprays.

**27.5 Generator System Requirements**

**27.5.1 Reliability Issues**

**Single Points of Failure**
The design of CEPS systems shall eliminate the vulnerability to a single event or failure disabling the whole, or a large portion, of the power station. The only exception to this is the provision of a single Control Room for the whole station as outlined above.

Any other potential single points of failure shall be identified and documented in the design report for Defence agreement.

**Unitisation**
Ancillary plant shall be arranged so that a failure of this plant only affects a single generating unit. In particular the ancillary systems, such as day fuel tanks, fuel pumps, starting compressed air receivers, etc. associated with a particular generator shall not be shared with other generators.
Redundancy
Critical common systems, particularly those with higher failure rates, shall be duplicated. In particular:

a) Duplicated DC supplies for control systems.
b) Duplicated bulk fuel storage.
c) Duplicated starting air compressors where air starting is utilised.

Segregation of Equipment
Critical systems and services shall be adequately separated so that a failure in one system does not affect adjacent systems. Particular attention shall be paid to separation of services between halls or other central locations.

Separation of Equipment from Adverse Environments
Where possible equipment shall be located away from extremes of temperature or vibration.

To the maximum extent that is practical all electronic components shall be located within the CEPS/CPS Control Room.

Fault Tolerance
Where common systems cannot be duplicated the system shall be designed to be tolerant of faults. In particular the system shall be capable of operating by alternate means in the event of a failure.

The Generator Control System (GCS) shall offer a manual control mode to mitigate against faults in the generator controllers or other parts of the generator control equipment. The control systems shall also comply with the requirements outlined in paragraph 27.6.2 below.

27.5.2 Mechanical System Requirements
Generating Sets

General
The engine shall be fitted with all protection devices necessary to ensure safe operation under the specified operating conditions.

The base frame of the generating set shall be isolated from the floor using seismic vibration isolators.

Supportability
Adequate local service support is therefore a key consideration in the selection of the generating sets.

In particular the generating sets installed within a CEPS do not normally operate for long periods and have relatively low running hours each year. They therefore are expected to be in service for a very long time. As such it is foreseen that their service life will eventually be determined by the availability of spare parts.
Rating
Generating sets need to be carefully selected according to their rating at a particular duty cycle. Larger sets are usually rated at different power output levels for three typical duty cycles:

a) Standby, where the set operates intermittently and for short duration, typically in response to a localised electrical fault;

b) Prime, where the generator operates for longer periods as the sole power source for a site with a varying load, typically on loss of supply; and

c) Continuous, where the generating set supports a load continuously, typically at establishments that are not connected to the mains grid but require a constant power source.

Sets for CEPS operations shall be rated for Prime duty under the service conditions expected within the power station.

Sets for CPS and CEP operation shall be rated for continuous duty under the service conditions expected within the power station.

Governing
Sets shall be capable of accepting or rejecting their full Standby rated load as a step load.

Starting Systems
Generating sets shall be started using either electric or compressed air starter motors.

Electric starting shall not be used where the use of alternative fuels that are flammable, such as Avtur are to be considered in the design.

Compressed air systems shall include:

a) At least two compressors (one electric and one diesel), one located in each generating hall;

b) Isolation valves between the generating halls to allow the system to continue functioning upon the loss of one hall, and

c) Separate air receiver for each engine.

Lubrication Systems
The lubricating system shall be a positive pressure using an engine driven positive displacement pump.

Oil filters shall be suitable for 500 hours of continuous operation without servicing. They mounted vertically with the engine connection at the top.

It shall be possible to check the engine sump level while the engine is running.

The engine sump shall be provided with a sump drain extended to an accessible position on the base frame and fitted with a ball valve. The ball valve shall be lockable against accidental opening.
The crankcase breather shall be extended to a position that prevents any fouling of the radiator core.

**Prime Sets**
On sets for prime power applications provide:

a) An oil manifold that allows oil filters to be changed while the engine is running without affecting oil flow to the engine.

b) An oil burn system that continuously adds oil to the sump using a dosing pump and burns the excess oil.

**Fuel Systems**
Fuel storage shall be provided adequate to continuously run the entire station at full load for the following periods:

a) CEPS, or stations with a CEPS role: 96 hours (4 days), unless agreed in writing by DEEP

b) CPS stations: 168 hours (7 days), subject to local supply limitations. In particular consideration must be given to events that can isolate the site (flooding, for example) and their potential impact mitigated by correct sizing of the bulk storage.

c) CEP stations: 24 hours (1 day)

Smaller fuel storages might be considered if:

a) There are large storages of alternate fuels on the site that can be used to refill the CEPS fuel storage, or

b) The proposed size of the fuel storage will create fuel management issues. In particular if it is projected that the testing and normal operation of the station will result in the fuel inventory taking in excess of two years to turn-over.

Bulk fuel installations shall generally be underground, with a minimum of two, dual skin tanks with interstitial space monitoring connected and alarmed to DESN.

For fuel dispensing operations, the surrounding area shall be designed to safely accommodate fuel spills. Concrete bunding or channelling and underground fuel traps may be used to contain fuel spills. The bunded area shall be covered or have some automatic means of emptying any rainwater.

It should be noted that, particularly where Avtur is used, a fuel spill could create a hazardous area near the ground (see Avtur Characteristics, below). Electrical equipment in this area may need to be selected for hazardous area use.

Day tanks shall generally be provided. These shall be fitted with an independent fuel shutoff so that they cannot be overfilled should a fault develop with the control system or return fuel lines.

The generating hall floor shall fall towards the floor trenches or a large sump. The trench/sump shall be fitted with sensors so that a fuel spill is detected and fuel supply is isolated.
Alternative Primary Fuels
Diesel engines can burn a variety of fuels other than diesel, albeit with various drawbacks. If there are large storages of these alternative fuels on the site at which the power station is being constructed their use as an emergency fuel shall be considered in the design to the extent to which this can be done without adding significantly to the overall cost. These alternative fuels might be present in the fuel tanks as a cocktail with diesel.

The main alternative fuel is Avtur, which is often available if the site supports aviation operations. The main disadvantage of Avtur is that it is a flammable liquid, however there a number of other issues as discussed below.

It is presently intended that the station exclusively use diesel as a fuel and there is no intention to change this policy at this stage. The design of the power station will consider the requirements for alternative fuels, such as Avtur or diesel/Avtur cocktails in the design. The following discussion on the use of Avtur and diesel / Avtur cocktails, is provided as background information only and should not be taken as definitive.

AVTUR Characteristics
a) Avtur is classified (refer AS 1940) as a flammable liquid and is potentially more hazardous from a fire or explosion perspective than diesel, which is classified as combustible.

b) Avtur has lower energy content than diesel. Hence the same engines operating under the same fuel delivery conditions will deliver lower output when operating on Avtur.

c) Viscosity information on Avtur is not readily available, as the relevant standard does not require it to be measured. Information available (such as the Report on “Use of Aviation Turbine Fuel JP-8 as the Single Fuel on the Battlefield”) reports a viscosity of 1.26cSt at 40ºC for the JP-8 fuel used for their testing. JP-8 is equivalent to both NATO Code F-34 fuel and to Avtur.

d) Avtur with FSII absorbs moisture and causes corrosion of fuel components.

e) Avtur has higher volatility than diesel fuel and when it is drawn from a tank by suction is likely to vaporiise.

f) Avtur is not miscible with diesel and has a tendency to separate out over time.

Hazardous Area Issues
Avtur is flammable liquid and so presents a potential explosion hazard if exposed to (electrical) devices where arcing or sparking may occur, and to temperatures above 38ºC as will be encountered in the Generator Hall.

Even though the Avtur is only a component of the fuel its presence has a potential to create a flammable gas atmosphere out of proportion to its percentage in the fuel mix. Therefore, there are hazardous areas surrounding the fuel pipe work, including the pumps, flanges and valves.
**Engine Output Issues**
The use of lower energy fuels means that for the same power output the engine uses more fuel. Disregarding other factors, the absolute maximum power output of the engine is therefore limited by how far the fuel rack opens. It should be noted that the engines have a standby rating which is approximately 10% above prime rating. This means that the fuel rack is capable of moving beyond the 100% prime power position to accommodate the lower energy fuel.

**Engine Operating Issues**
Aviation fuel and kerosene are often used in operating diesel engines in cold climates. With the higher ambient temperatures, the viscosity of exclusive Avtur fuel is lowered to such an extent that reduced self-lubrication of the fuel system becomes an issue.

For a typical diesel engine, a minimum viscosity of 1.5cSt at 38°C is required at the engine transfer pump to properly lubricate the fuel system components.

The operation of the generating set diesel engine on exclusive Avtur is feasible but there would be a loss of operational life compared to operation on diesel due to the lower viscosity / lubricity of the fuel. It is noted that Avtur has a lubricity improver added; however the effect on the life of a diesel engine is unknown. Short-term or infrequent operation on Avtur or the use of diesel / Avtur cocktails is not expected to significantly reduce engine life.

**AVTUR Corrosion Issues**
Problems have been experienced due to the absorption of water vapour by Avtur and consequent corrosion of storage tanks and fuel lines. Industry practise has increasingly moved away from mild steel tanks and lines, and toward the use of coated tanks and stainless steel fuel lines.

**AVTUR Volatility Issues**
The characteristics of Avtur effectively prevent it being drawn from a tank by suction. Hence the use of Avtur could require the provision of a long-column tank-mounted pump with impellors immersed in the liquid or a pump at a lower level than the tank. Immersed “dispenser” pumps such as the “Red Jacket” pump widely used in the commercial / retail petroleum sector are capable of pumping diesel and Avtur when used in this duty.

**AVTUR Miscibility Issues**
While Avtur is lighter than diesel, it is not inherently miscible with diesel, and exhibits a tendency to globulate or separate out of mixture. To address separation / stratification issues fuel circulation pumps would be required to mix the fuel in the storage tanks. This would ensure that a fuel cocktail was delivered through the fuel reticulation system to the engines as a homogeneous mixture.

**Cooling Systems**
In general radiators for standby applications shall be set mounted and prime power applications shall be remote.

Radiators shall be sized to make allowance for not less than 20% reduction in heat transfer capacity as a result of fouling.
The radiator fan shall be sized to provide adequate cooling airflow allowing for any external pressure drop as a result of the inlet and outlet flow path. Where the fan draws air through the generating hall this can include the inlet flow path and/or attenuators, and the outlet flow path and/or attenuators.

**Exhaust Systems**
Exhaust piping shall consist of spirally welded 302 or 304 stainless steel piping sized in accordance with the engine manufacturer’s recommendations.

Exhaust piping within the building shall be lagged using mineral fibre insulation (not fibreglass), suitable for service up to 650°C, not less than 75 mm thick. The insulation shall be sheathed throughout using 0.5 mm zincalume sheet steel or stainless steel.

The exhaust system and silencer shall be supported on spring suspension hangers to minimise vibration transfer to the structure.

A suitable cowling shall be provided to prevent rain entering the exhaust system. Where passive defence measures require, ensure that the exhausts do not directly exit the building.

The silencer shall be provided with a drain to remove condensation. This drain shall run to a 0.6 litre capacity open top container near ground level to allow the condensation to evaporate.

**Ventilation**
Generally, where set-mounted radiators are employed, the radiator fans shall be positioned to draw cooling air into the generator hall via a louvered and vermin-proofed penetration in the building wall.

Where use of the radiator fans alone is not considered adequate, additional thermostatically controlled ventilation fans may be installed.

For Bases in cyclone-prone areas where the power station is desired to operate during a cyclone, the ventilation intake and outlet shall be installed on the same side of the CEPS building, with care taken to ensure adequate cooling in all areas of the hall. This practice creates a pressure-equalised building, which allows the ventilation system to continue operating in cyclonic conditions where a significant pressure differential may develop across the building.

The direction and temperature of the exhaust air from the power station should be considered where identification of the power station using its thermal plume has been identified as a risk in the Threat Assessment.

**27.5.3 Electrical System Requirements**
**Wiring Systems (WS) Classification**
In addition to the requirements for hazardous areas the wiring systems shall provide resistance to damage from mechanical factors and fire consistent with the environment and the purpose of the installation. The required WS classification shall be indicated in the design documents.
Wiring systems within 2 metres of the floor of generating halls should be minimum WS2X.

**Electrical Connection**
The standard configuration for Defence establishment distribution networks is described in the LV and HV Distribution Systems IM.

In brief:
- a) An establishment has multiple points of electrical supply;
- b) The HV distribution is divided into rings, with each ring starting and terminating at a different electrical supply point;
- c) Dedicated Interconnector cables exist between supply points to facilitate power transfer in the case of partial supply failure; and
- d) The CEPS is located at a supply intake point.

The generating sets shall operate in parallel, sharing equal portions of the load, and connect to a section of the intake bus such that generators may operate in parallel with external mains supply or as the sole source of power.

The various modes of HV network operation are described in Chapter 3 – High Voltage System Master Plans and Project Development Plans and Chapter 26 – High and Low Voltage Distribution System Requirements.

**Generator Alternators**
Alternators shall generally be self-excited, brushless 400 volt synchronous machines. Where the sets connect to a high voltage network unit step-up transformers shall be used. The generating unit shall be provided with an automatic voltage regulator (AVR) designed to offer regulation to \( \pm 1\% \) for power factors between 0.8 and unity for all load levels.

Should physical constraints preclude the use of step-up transformers the use of high voltage alternators can be considered subject to DEEP agreement.

As with all other generating components, the alternators shall be selected on the basis of reliability, availability and quality of local support services from the manufacturer or their representative.

**Alternator Protection**
Provide a protection-grade specialist generator protection relay to provide electrical protection of the alternator on generating sets with the following protection elements:
- a) Over current;
- b) Earth fault;
- c) Reverse power, and
- d) Stator winding temperature.
- e) Over voltage;
- f) Under voltage;
- g) Over frequency;
For generating sets rated above 800 kW, or those which power high voltage electrical networks under normal operation the following additional protection elements shall be provided:

a) Generator biased differential;
b) Voltage dependent over current;
c) Loss of excitation;
d) Over fluxing;

**DC Systems**

The control system shall be powered from a redundant, battery-backed DC supply.

The system shall consist of:

a) Two hot-swappable battery chargers (A&B), each capable of supplying the full load of the control system while charging one battery bank in a period of less than 16 hours from 90% discharged;

b) Two battery banks (A&B), each capable of supplying the full load of the control system with all equipment running for a period of more than 16 hours without mains supply.

c) A DC switchboard with two bus sections. The switchboard shall incorporate:
   
   - A separate circuit from each bus section to each control panel;
   - A separate circuit from each bus section to each other control system load that is connected directly to the switchboard;
   - Sufficient switching so that each battery and charger can be disconnected from the bus or that the two buses can be cross connected.

Chargers shall be capable of running in parallel. The battery system shall be fitted with all protection devices necessary to ensure safe operation under the specified operating conditions. It shall be appropriately monitored by DESN.

In the event of failure of one DC bus, the system shall automatically changeover to the other.

Batteries shall consist of single strings unless parallel strings are specifically required by DEEP.

Batteries shall have sealed cells with a design life of at least 10 years under the conditions in which they are installed.

Battery systems shall only be sourced from manufacturers with prominent factory support within Australia and preferably within the region where the sets are installed. They shall be of a model with a large installed user base in the local region.

At each load there shall be either:

a) An arrangement to select which DC bus is connected, or

b) Contactors so that the equipment can seamlessly take supply from either DC bus.
HV Requirements
Requirements for the HV installations are contained in chapter 26. Particular attention is drawn to the requirement for synchronism check relays on HV circuit breakers.

It is preferred that the alternators be solidly earthed however the use of resistive/reactive earthing or Neutral Earthing Contactors (NEC) might be necessary to limit the impact of circulating currents.

27.5.4 Control System Requirements

Reliability Issues

Segregated Control Panels
Each generator shall have its own segregated Generator Control Panel that houses the Generator Controller, the AVR, and governor/load sharing module and all local indication and control pushbuttons specifically for that generator.

A Station Control Panel shall be provided to house the GCS Station Controller, the GCS Network Hubs and any general local indication and control associated with the power station including the mimic panel, but not directly related to any particular generator.

Wiring from one control panel to another shall not generally pass through other control panels.

Fault Tolerance
Each generator shall be capable of operating independently following a failure of the GCS Station Controller or other Generator Controller, or their associated systems. In the event of failure of the GCS Station Controller or systems this is expected to require operation of the generator in the manual mode. As a minimum this shall include:

a) Dedicated Controllers - Each generator shall incorporate a dedicated Controller to monitor and control its respective auxiliaries and operating parameters.

b) Dedicated Control Equipment - Each generator shall incorporate dedicated synchronising, speed control and voltage regulation equipment.

Communications Segregation
A dedicated communications network, independent of the Defence Engineering Services Network (DESN) or any other network, shall carry all internal traffic between the elements of the GCS.

All serial communications between GCS components, whether this is Ethernet, RS485 or other protocols, shall occur through hubs. Hubs shall be located in the Station Control Panel.

Hazardous Areas
Control Systems shall not be located in hazardous areas or explosives areas as defined by the appropriate regulations, codes and standards.
Control Panel Requirements

Location
The Station Control Panels and Generator Control Panels shall be located side-by-side in the Control Room, preferably on the wall adjoining the generating hall/s.

The Station Control panel shall be located in the middle between the Generator Control Panels for each hall. The order of the Generator Control Panels shall match the physical order of the generating sets when seen from the front of the panel.

Metering
All analogue information displayed on control panels or generator set gauges shall be input into the Controller for monitoring and trending purposes.

Operator Interface
The operator interface for each panel shall consist of a single integrated panel, not a collection of display panels from various manufacturers.

The operator interface for each Generator Control Panel shall be similar and these should have a common look and feel with that provided on the Station Control Panel.

Similar events and operations between panels shall be displayed and occur in a consistent fashion.

There should be sufficient indicators and meters to easily and accurately portray the state and condition of the whole plant to semi skilled operators. The following are typical examples:

a) The operator should understand why the generator is running, e.g. when it is in cooling down mode, and
b) It should not be possible for a set to trip or shutdown a generator or function without an indicator illuminating on the appropriate panel. This also includes any grouped trips. Similarly, it should be obvious to an operator why a set won't or could not operate.

The controls shall be arranged in a logical and ergonomic manner with commonality of all control switches, indicators, meters and the like. Devices shall be of the type most suitable to convey their purpose. For example:

a) Circuit breaker status should be indicated by semaphore;
b) Meters for comparative purposes should be together;
c) Colour should use to indicator status/purpose, and
d) Illuminated push buttons can be misleading and confusing and should not be used.

Only one operator should be used to serve one purpose in each panel, i.e. one push button for alarm acknowledge. Provide a lamp test facility on each panel to test all lamps, LED's, etc. on that panel.
The control parameters used by the control system, such as timers etc, must be site programmable without the need for any software or hardware changes. The programmable settings should be easily changeable via the associated control panel.

Indication and control on Generator Control Panels and the Station Control Panel may be provided by LEDs, LCD displays or HMI panels, however as a minimum the following shall be provided independent of the operation of any LCD display or HMI panel. Switches and indicators shall be oil-tight 22mm series.

a) Station Control Panel
   - Station Mode Switch.
   - Spinning Reserve on front of panel, other thumb wheel inside (e.g. feeder demand, peak lopping, etc)
   - Load shed controls
   - HV Mimic Panel
   - Electrical metering as detailed below

b) Generator Control Panels:
   - Generator Mode Switch;
   - Emergency Stop pushbutton;
   - Generator Start/Stop pushbuttons;
   - Generator circuit breaker Open/Close pushbuttons;
   - Neutral Earthing Contactor Open/Close pushbuttons;
   - GCB semaphore;
   - NEC semaphore;
   - Generator Running indicator, and
   - Generator Fault indicator
   - Electrical metering as detailed below
   - Generator status indicators as detailed below

**Standard LED Based Panel Requirements**
Acceptable panel arrangements are provided in Figure 27.1 and Figure 27.2 as detailed below:

**Standard Arrangement Drawings**
- Figure 27.1: Typical CEPS/CPS Panel Details
Figure 27.2: Typical CEPS/CPS HV Mimic Panel Details
HMI Panel Requirements

Defence places great importance on ensuring uniform operator interfaces and therefore HMI panels must ensure common functionality is achieved with the general arrangement of the LED specified above. Where it is proposed that HMI panels be used DEEP requires the system topology and screen layouts including a SCADA map for endorsement prior to finalising the design.

Each HMI panel shall be full colour and of such size and resolution so as to enable easy viewing of the on-screen data.

Touch screen panels shall not be used.

In addition to providing indication and status display, HMI panels may be used to set/adjust the following values:

a) Trip frequency tolerances
b) Trip time delays;
c) Generating set capacity; and
d) Load shedding values

When this approach is used, provide password protection of the values to prevent inadvertent changes and perform a self-check of the values to ensure values are within acceptable ranges.

Operator screens shall be easy to negotiate and be structured in a logical manner according to:

a) Generator set;
b) System Type; and
c) Importance.

The generator status shall always be displayed on each page so that it is always possible to see what is happening with the set.

Similarly it shall always be possible to see what the overall station is doing and why.

Generator Control Panels

In addition to any controls and indicators described elsewhere, provide the following at each Generator Control Panel:

a) Metering of electrical parameters;
b) Metering of engine parameters;
c) Status of generator set including:
   – Running
   – Synchronising
   – Online
   – Cooling down
– Engine Stopped
– Not available
– Call to Start
– Call to Stop

d) Individual indicators for each Warning and Alarm condition.

**Metering**

The level of metering provided for each generating set will be dependent upon the installation and in particular the size of the generating set. As a minimum the following level of metering shall be provided on all generating sets:

a) Frequency;
b) Volts (each phase);
c) Current (each phase);
d) Power factor;
e) kWh;
f) Hours run;
g) Speed;
h) Oil pressure after filter
i) Cooling water outlet temperature;
j) Starting battery volts or air pressure.

For generating sets above about 800 kW the following additional metering shall be provided:

a) Oil pressure before filter;
b) Oil temperature;
c) Cooling water inlet temperature;
d) Combustion air temperature;
e) Exhaust temperature (each bank);
f) Alternator winding temperatures;
g) Alternator bearing temperature;
h) Boost pressure;

Where the metering being provided is to a lower level than described above the designer shall detail this in the CDR.

Metering for kWh and Hours Run shall be from the controller.
Generator Warnings
In response to the operation of an engine or alternator warning shutdown the set when another set is online to take over (see paragraph 27.5.5 Control Philosophy). Reset the warning flag upon removal of the condition and the Reset button being pressed.

Provide sufficient Warnings for each generator set such that adequate indication is provided of any pending alarm. Generally provide warnings for the following:

a) Low Pressure Condition;
b) High Temperature Condition;
c) Fuel High/Low;
d) Overload Condition;
e) Neutral Earthing Contactor (NEC) fault;
f) Non-critical generator ancillary faults; and
g) Other warnings as necessary to annunciate generator set is not healthy i.e. Controller alarm, synchroniser alarm etc.

Generator Shutdown Alarms
In response to a Shutdown being initiated immediately:

a) Open the generator circuit breaker
b) Remove excitation and, after a cool-down period
c) Stop the generating set.
d) Flag the set as being Not Available and lockout any attempt to start the set. Reset the flag and lockout when the condition is removed and the Reset button is pressed.

Provide sufficient Alarms for each generator set such that equipment does not reach a damaging state or limits that damaging state. Generally provide Alarms for the following:

a) Alternator over temperature;
b) Set underspeed / overspeed;
c) HV Protection Relay fault;
d) HV Protection Shutdown signal including the individual display for actual protective element that has operated;
e) Fail to synchronise;
f) Low Fuel;
g) NEC Fault;
h) Any other trip that is required to ensure that the generator set or associated equipment does not reach a damaging state or if it does then the limit of damage is a minimum.

Generator Trip Alarms
In response to a Trip being initiated immediately:
a) Open the generator circuit breaker;
b) Remove excitation and stop the generating set;
c) Flag the set as being Not Available and lockout any attempt to start the set. Reset the flag and lockout when the condition is removed and the Reset button is pressed.

Provide sufficient Trip Alarms for each generator set such that equipment does not reach a damaging state or limits that damaging state. Generally provide Trip Alarms for the following:

a) Generating Hall Fire Alarm;
b) Controller Failure;
c) Bearing over temperature;
d) Generator and HV Protection Trip signal, including an individual display for the actual protective element that has operated;
e) Any other trip that is required to ensure that the generator set or associated equipment does not reach a damaging state or if it does then the limit of damage is a minimum.

**Generator Starting System Alarms**

In response to an alarm being initiated immediately:

a) Flag the alarm and lockout any future attempt to start the set. Reset the flag and lockout when the condition is removed and the Reset button is pressed.

Provide the following alarms:

a) Starting air low pressure or starting battery low voltage for more than 15 minutes continuously.

If the set is already running it shall remain running. Any lockout shall only take effect once the set stops.

**Station Control Panel**

In some older systems this panel is often known as Common Services.

In addition to any controls and indicators described elsewhere the Station Control Panel shall house the Station Controller. The Station Mode selector switch, HV mimic and load shedding controls shall be mounted on the front.

Provide indicators and meters to indicate the overall status of the station and the incoming feeders so that it is immediately obvious as to why the station is running, or not.

Provide indicators and meters to indicate status of all common or ancillary systems, such as fuel systems. Sufficient of these should be independent of the Station Controller such that if this controller fails then the Station can still be operated manually.

**Indicators**

In addition to indicators for the station auxiliary systems the following indicators shall be provided:
a)  Restricted Operation – Any condition that restricts the automatic operation of the power station, such as if the CEPS bustie is open;

b)  Mains fail;

c)  Lack of Capacity – Insufficient generating capacity to meet the load and spinning reserve;

d)  Load Shed – Load shedding operations in progress;

e)  Peak Lopping – Peak lopping operations in progress.

f)  Feeder Limit – Feeder demand limit operations in progress;

g)  LEG Run on – LEG Run On signal active

**Warnings and Alarms**

Provide warnings and alarm signals for all major items of station plant.

The following minimum alarms shall be provided:

a)  Fire alarm for each generating hall – Shuts down the generating plant and fuel supply in the affected hall;

b)  Air compressor alarms;

c)  Neutral earthing alarm;

d)  Ventilation faults;

e)  Battery supply faults;

f)  Fuel tank low level alarms;

g)  Generating hall high temperature

**Metering**

As a minimum the following level of metering shall be provided:

a)  Bulk fuel tank levels

b)  Generating hall temperatures;

c)  Control room temperature;

d)  Starting air system pressure;

e)  Control battery voltages;

f)  Voltage and Watts at each incoming feeder.

g)  Voltage at each bus (ISS, CEPS1 and CEPS2)

h)  Frequency at each CEPS bus (CEPS1 and CEPS2)

i)  Combined Watts and power factor being supplied from the mains.

j)  Combined Watts and power factor being supplied by CEPS.

Frequency, voltage, VA, current and power factor in the HV system shall be provided as 96 mm, 90-degree scale, analogue meters mounted above the control panel.
Mimic Panel

Construction
The mimic shall consist of an aluminium plate that is screen printed with the mimic layout of the establishment system.

The mimic shall be located on the front of the Station Control Panel.

Alternate mimic arrangements will be considered, but require the approval of DEEP.

Indicators
The following indicators shall be located on the mimic:

a) Power Available indicator (Red) for each incoming feeder;

b) Status indicators for each HV CB and NEC, including:
   – Semaphore for Open/Closed status;
   – Tripped status indicator (Yellow) for each HV CB;
   – Manual status indicator (White) for each HV CB that is under manual control from the mimic;
   – Local (Remote control Inhibited at CB) status indicator (Blue);

c) Running and fault indicators for each generating set. These signals shall be derived directly from the devices not through the Station Controller.

Controls
The following controls shall be located on the mimic:

a) Auto/Manual mode selector switches for each HV CB that is under the control of the GCS;

b) Open/Close switch for each HV CB that is under the control of the GCS

Switches shall consist of 22 mm series, oil-tight rotary switches with centre spring return.

HV Access Key Switch
Provide a HV Access key switch that is a permissive on the operation of the HV Mimic as follows:

a) When the key is withdrawn:
   – A change to the Auto/Manual mode of the HV circuit breakers is inhibited
   – Manual operation of the HV CB in Manual Mode is inhibited.
   – Automatic operation of HV CBs in Manual mode is inhibited
   – Automatic operation of HV CBs in Auto Mode is permitted

b) When the key is inserted:
   – A change to the Auto/Manual mode of the HV circuit breakers is permitted
   – Manual operation of the HV CB in Manual mode is permitted.
   – Automatic operation of HV CBs in Manual mode is inhibited
   – Automatic operation of HV CBs in Auto Mode is permitted
Insertion or removal of the ‘HV Access’ key shall be bump less. The Auto/Manual mode shall remain unchanged when the key is inserted or removed.

An acceptable HV Mimic arrangement is provided at Figure 27.2.

**Load Shedding Panel**
A load shedding panel shall be provided that allows the individual selection of automatic and manual control of each load shedding group. The operation of this panel shall be entirely independent of the Station PLC/Controller to enable the load shedding to be operated in the event of PLC/Controller failure.

The panel shall contain the following:
- **a)** An Auto/Manual rotary switch for each load group;
- **b)** A Shed//Connect spring-return rotary switch for each load group;
- **c)** A Manual (Yellow) that lights if any load group is in Manual control;
- **d)** A Shed (Blue) indicator for each load group;
- **e)** A CEPS Operating (Green) indicator;

Switches and indicators shall be 22 mm oil tight.

Transfer between Automatic and Manual mode shall be bump less.

An acceptable load shedding panel arrangement is provided at Figure 27.1

**Alternator Protection**
Where a specialist generator protection relay is required it shall be configured to provide the following voltage free outputs:
- **a)** Trip Prime Mover: This signal is generated if a fault is detected by the protection relay that will cause further damage if the generator continues to rotate. This signal is latching.
- **b)** Shutdown Prime Mover: This signal is generated if a fault that will not cause further damage if the generator continues to rotate is detected by the protection relay. This signal is latching.

After each of the above signals is received the Generator Controller shall take the required action and interrogate the protection relay to determine the individual protective element that has operated.

Each generator protection relay shall have a voltage free contact to indicate Healthy status (watchdog). The Generator Controller shall use this contact to determine if the protection relay has a fault.

Where a specialist protection relay is not required the above functions shall occur entirely within the Generator Controller.
Feeder Protection
Where parallel operation of the power station with the mains is possible the HV protection shall protect against the following contingencies while running in parallel with the mains:

a) A fault on the HV network external to the facility. This shall be done using directional overcurrent protection on the incoming feeders as a minimum.

b) A failure of the mains supply. This shall be done using a combination of the following means:
   – Intertrip signals from the NSP, where available.
   – Reverse power protection, where the station does not export power to the mains;
   – Vector shift or Rate of Change of Frequency (ROCOF) protection.

Protection for loss of the mains shall:

a) Open the incoming circuit breaker so that it does not lock out and can be reclosed by the GCS when the mains returns, and

b) Send a signal to the GCS. The GCS will then operate as for a mains failure.

Alternatively the above function can occur entirely within the Station Controller where this functionality exists.

Defence Engineering Services Network (DESN)
The DESN is an establishment wide control and data acquisition system generally consisting of networked data gathering points or Remote Terminal Units (RTUs) and a central operator interface. The system monitors and/or controls various engineering services, with particularly emphasis on the electrical power systems. On a number of bases the DESN is known by other names e.g. PCMS.

Where a DESN is not provided or has not been fully implemented, many control and monitoring functions are instead hardwired back to a central point, usually the CEPS.

Monitoring, Trending and Logging
Where a DESN has been provided, the DESN shall monitor, trend and log the status and condition of the CEPS plant, including load-shedding commands.

Provide all necessary DESN software and hardware for the DESN to perform this function. This shall include the provision of dedicated display pages covering the CEPS plant and the integration of CEPS alarms/warnings into the DESN alarm-handling algorithm.

The GCS shall pass all plant analogue and event/alarm/warning data to the DESN in such a manner that the DESN is not able to write to the GCS registers or affect the operation of the GCS. It is preferred that this requirement be implemented by some form of hardware firewall.

LV Load Shedding
Where a DESN has been provided it is generally in direct control of the low voltage load shedding devices (where these exist). Alternatively, at older establishments the low voltage load shedding devices can be hardwired back to some central location (usually within the CEPS).
Provide an interface at the GCS to the DESN and/or the hardwired load shedding device. The signals from the GCS shall consist of voltage free contacts, one for each load-shedding group. Also provide a voltage free contact to indicate that the CEPS is operating, i.e. any of the generating sets is running and connected and an analogue output of the Available Capacity.

**LEG Run-on**

LEG Run-on signals are provided to the LEGs so that they continue to run on power failure, even after the CEPS is supplying the Base.

Where a DESN has been provided it is generally in direct control of the LEG run-on. Alternatively, the run-on is hardwired back to the CEPS.

Provide an interface at the GCS to provide the run-on signal consisting of voltage free contacts. Connect this to the DESN and/or the hardwired control cabling system to achieve the run-n function.

Provide an Auto/Force Off/Force On key switch within the Station Control Panel to provide manual override of this function.

### 27.5.5 Control Philosophy

**Control Philosophy Definitions**

**Available:** Generating sets are available if they are in Duty or Standby mode and do not have an alarm showing.

**Available Capacity:** The On-line capacity less the Spinning Reserve.

**Call to Start:** A signal from the Station Controller to a Generator Controller to start, synchronise and connect the generating set. The set remains unloaded until separately commanded to assume load by the Station Controller. The Call to Start shall remain active while ever the generating set is required to run. The Call to Start is removed when the Station Controller issues a Call to Stop.

**Call to Stop:** A signal from the Station Controller to a Generator Controller to unload the generating set, open the generator circuit breaker and after the required cool down period stop the engine. The Call to Stop is removed when the engine has stopped.

**Capacity Control:** The control algorithm that ensures that the correct number of generating sets are operated to supply the present load. When Capacity Control is disabled the system shall operate all available generating sets independent of the load connected.

**Feeder Demand Limit:** A defined capacity (in MVA) for each incoming feeder.

**Load Shedding Control:** The control algorithm that ensures that the connected load is within the capacity of the CEPS. This is achieved by shedding individual facility loads on the LV system and by course load shedding on the HV system. When Load Shedding Control is disabled all HV feeders and LV load groups shall connect.
Load Shedding Hysteresis: The capacity, in excess of the Spinning Reserve, that must be present for the load shedding system to attempt to connect new load groups. The hysteresis is a nominal value that limits the occurrence of shed-connect-shed hunting in the load shedding system.

Minimum Import Level: The minimum power transfer that is permitted on the incoming feeders while the generators are running in parallel with the mains. This is usually a requirement of the NSP, however where such a limit is not imposed by the NSP the limit shall be set so that the Station does not export power to the grid.

On-line Capacity: The prime capacity of the generating sets that are presently on-line and supplying Base load. A generating set shall only be included in the calculation if the following conditions are satisfied:

a) The set is running; and
b) Its generator circuit breaker is closed

Remaining Capacity: The Available Capacity less the System Load.

Spinning Reserve: The minimum reserve capacity that shall be available on the system at any time. The spinning reserve is at least equal to the largest load that can be expected to connect during normal system operation. This is usually the largest pump or other motor, or the largest load connected to a LEG.

System Load: The total electrical load presently being supplied. This includes all power station loads and system parasitic loads. The system load shall be a thermal load calculated by applying a first order filter, with a time period of 5 seconds, to the instantaneous values.

Assumed Configuration
The following control philosophy assumes the following electrical configuration also provided at Figure 3.1, Typical Base HV System:

a) Two HV points of supply, one to CEPS and other to ISS; it is assumed that the NSP only makes one supply available at a time by isolating the other supply at a point external to the Base.

b) One CEPS facility with generation, connected to a split generator bus;

c) Interconnector between CEPS and ISS;

d) Ring mains, generally running between ISS and CEPS.

The control system shall allow the normal operation of the CEPS with any on-base reticulation system configuration except where otherwise allowed in this Chapter. In particular, the CEPS shall continue to operate as a standby power station with any on-base HV configuration.

Modifications to this control configuration that are necessary as a result of other electrical configurations should be indicated in the FDB and be further detailed by the Designer in the CDR for DEEP agreement.
Figure 3.1 is copied again below for convenience.
- Figure 27.3: Typical Base HV System
Generator Control System (GCS) Hardware

The generator control system shall generally consist of the following individual items:

a) Station Controller including control, load sharing and mains synchronising functions;

b) An individual Generator Controller for each generator; including control governor, AVR, load sharing and generator synchronising functions;

c) Generator Control Communications Network;

d) DESN interface;

e) Protection relay interface;

f) Local indication and controls as required.

Maximum use shall be made of open systems and protocols.

Multifunction Generator Controllers that perform multiple tasks that would normally be performed by separate items of equipment are permitted. However, load sharing and control for the generators shall be separate to the GCB protection relays.

HV System Operating Modes

Operation

All HV circuits at CEPS and ISS, with the exception of the generator and auxiliary transformer CBs, shall be under the control of the Station Controller. This enables the GCS to open and close these circuit breakers in coordinated response to a power outage or initiate load shedding, should this be required. The auxiliary transformer CBs shall not be controlled by the GCS and shall be only operated locally at the HV Switchboard.

The generator CBs and any generator Neutral Earthing Contactors (NECs) shall be under the control of the individual Generator Controllers and are controlled with the generating sets (see Generating Set Operating Modes).

HV CB Manual Mode

In manual mode the operation of the HV CB shall be from a rotary, centre spring return, “Open/Close”, control switch located on the mimic.

HV CB Auto Mode

In auto mode the operation of the HV CB shall be from the GCS.

Failed Automatic Sequences

A failure of the following HV CBs to operate either:

a) An incomer HV CB to open or close, or

b) A GCB to open

In response to a command under an automatic sequence will affect the execution of the subsequence sequence as follows:

a) Initially flag a warning and suspend the sequence until the CB operates. Recomence the sequence when the CB operates.
b) If the sequence is still not complete after 30 minutes flag an alarm and the abort the sequence.

For example the failure of a GCB to open when the generator is being taken off line will result in the set continuing to run indefinitely at no load. A warning will be flagged initially and an alarm after 30 minutes.

Such an event could occur if the CB is in Manual mode at the mimic, in Local mode at the CB or as a result of a fault.

Note: A failure of a GCB to close when synchronising will result in a Fail to Sync alarm being flagged in a quicker timeframe in accordance with the standard Generator Controller requirements.

Failure of an Interconnector or ring main HV CB to operate in response to a command shall be ignored.

Generator Operating Modes

Operation
Each generating set, and its associated HV CB and NEC shall be under the control of its own Generator Controller. The Generator Controller shall be able to start and stop the set, and to initiate synchronisation and control the NEC even if the Station Controller or the GCS network is not operational.

The controls for each generating set and its associated HV CB and NEC shall be located within separate control panels segregated from the others and the Station, so that a failure in one panel will not affect the whole station.

An individual Emergency Stop consisting of a red, mushroom head pushbutton that is turn-to-release shall also be mounted on each Generator Control Panel.

Mode Selection
Each individual generating set shall have a single, rotary, “Manual/Off/Duty/Standby” selector switch that determines the operating mode of that generating set and its associated HV CB and NEC.

A suitable time lag shall be incorporated in processing the mode selection to allow one mode to be selected directly from any other mode in a bump less transfer.

Generating Set Operation

Manual Mode
In manual mode starting and stopping of the prime mover shall be from Start and Stop pushbuttons. The GCB shall be controlled from Open and Close pushbuttons. When the Close pushbutton is pressed the generating set shall synchronise with the mains and the circuit breaker close. When the Open pushbutton is pressed the circuit breaker shall immediately open. If the Open pushbutton is held, the control system shall carry out a ‘soft unload’ of the
generators. The circuit breaker shall open immediately on release of the button or when the sets are unloaded.

**Duty and Standby Modes**

In either Duty or Standby mode the generating set shall start, synchronise and connect in response to a Call to Start from the Station Controller. It shall also disconnect, and cool-down and stop in response to a Call to Stop from the Station Controller.

**Synchronisation**

The first set to reach speed shall connect to the HV Bus by closing its HV CB subject to automatic dead bus control. The other sets shall synchronise with the live HV bus and close their HV CBs, thereby connecting to the HV bus. The automatic start, synchronisation and bus connection shall be coordinated to avoid two machines “racing” each other and both connecting to what appeared to be a dead bus.

**HV Neutral Earthing Operation**

**Run-up, Shutdown and Alarms**

It is preferred that the generator circuit be protected from earth faults during run-up and shutdown using neutral displacement protection. If neutral displacement protection is provided the NEC shall be open whenever the GCB is open. If neutral displacement protection is not provided the neutral earthing contactor shall be closed while the GCB is open during run-up and shutdown in all operating modes.

Following operation of a protective device the NEC shall operate as follows:

a) Generator Protection Trip: The NEC shall open and remain open

b) Generator Protection Shutdown: The NEC shall close when the GCB is open and remain closed until the generator stops.

**Manual Mode**

The NEC shall operate as described above for Generator start-up and shutdown.

During synchronisation the Generator Controller shall monitor the bus voltage on the bus to which it is about to connect. If the bus voltage is healthy it shall assume that the HV system already has an earth reference and open its NEC when the GCB closes. If the bus is dead it shall close its NEC when the GCB closes.

If at any time the NEC Open or Closed pushbuttons are pressed then the NEC shall operate in response.

**Duty and Standby Modes**

When the generator circuit breaker is closed the NEC shall close and open in response to a command to the Generator Controller from the Station Controller.

The Station Controller shall ensure that there is one, and only one, earth reference on the HV system, whether this be the mains or a NEC.
Should a NEC fail to operate when commanded then flag a NEC Fault for that set. It shall then attempt to close a NEC on another set.

If the situation is not corrected within 5 minutes then flag a Neutral Earthing alarm.

**Station Operating Modes**

**Mode Selection**
The Station Control Panel shall have a single, rotary, “Test/Standby/Prime” selector switch that determines the operating mode of the entire power station.

A suitable time lag shall be incorporated in processing the mode selection to allow one mode to be selected directly from any other mode in a bump less transfer.

**Station Test Mode**
Test Mode is used to periodically load test the generators. This is done by running the sets against the mains and transferring the Base load to the sets.

If it is desired to load test a single set the remaining sets should be set to Off mode at their respective Generator Control Panels.

Capacity Control and Load Shedding Control shall be disabled so that all Available sets run and all load is connected.

Test Mode can only reliably operate when the HV distribution system is in its normal “closed up” configuration. If the HV system is split as a result of a CEPS/CPS Bus-tie being open or an Interconnector cable being out of service the GCS cannot easily identify how its actions will affect the power flows in the HV system or the incoming feeders. In order to prevent undue complications in the control system Test mode shall be disabled if the CEPS/CPS Bus-tie is open or an Interconnector cable is out of service. The Station Control Panel shall have a suitable Test Mode Disabled indication.

**Starting Test Mode**
Upon Test Mode being selected the Station Controller shall sequentially:

a) Issue a Call to Start all Available sets. (The Station Controller programming shall allow for starting of all sets, including those indicated as future, but shall only effect the starting of those installed initially). In response the individual Generator Controllers shall start the set synchronise with the mains, close their associated generator HV CB and remain unloaded until all available sets are connected.

b) Progressively load all generators to 100% of prime capacity as derated for the site and service conditions. Should the load of the Base be less than the connected generator capacity, then limit the load on the generators so that the Base always imports the defined Minimum Import Limit. During this period, no power shall be exported from the Base into the Grid.
Mains Failure
A failure of the mains supply while running in test mode will be detected by the incoming feeder protection. The HV protection will open the connected incoming feeder circuit breaker to isolate the mains supply and provide a digital signal to the GCS. The GCS mains fail alarm shall remain latched in order to alert the operator to the mains failure.

In response to this event the Station Controller shall sequentially:

a) Provide “LEG Run-On” signal to the PCMS.
b) Enable Load Shedding Control. HV ring mains shall remain closed unless commanded to open by the Load Shedding Control
c) After a programmable delay (from 0 to 20 minutes, initially set at 5 minutes) to reach stable load, enable Capacity Control to operate the appropriate number of generator sets.

Mains Return
A return of the mains supply will be detected by the phase failure relay/s on the HV switchboard incomers. In response to this condition being continuously present after a programmable time period (0 to 30 minutes, initially set at 5 minutes), the Station Controller shall sequentially:

a) Synchronise to the mains and close the incoming feeder HV circuit breaker to reconnect mains supply.
b) Withdraw the “LEG Run-on” signal from the DESN to allow shut down of LEGs.
c) Remove Capacity Control, which will start and synchronise all available duty/standby sets.
d) Disable Load Shedding Control, which will reconnect all loads. Reconnection of loads back to mains shall be done in a progressive manner to avoid large load steps to the NSP.
e) Restore Test Mode operation.

Selecting Standby Mode When Mains Available
When Test mode is de-selected and Standby is selected when the mains is available, the Station Controller shall sequentially:

a) Remove the Call to Start and issue a Call to Stop to all sets.
b) When each set stops remove its Call to Stop.
c) If the mains should fail before expiration of the cool down period, the system shall respond with a Black Start as per Standby mode except the generators are already running.

Selecting Standby Mode When Mains Unavailable
When Test mode is de-selected and Standby mode is selected after the mains has failed, the Station Controller shall:

a) Continue to run the generators
b) Operate in accordance with Standby mode.
**Selecting Prime Mode When Mains Available**
When Test mode is de-selected and Prime mode is selected when the mains is available, the Station Controller shall sequentially:

a) Disable the minimum import limit on Test Mode, allowing the generators to run to full load.

b) Enable Load Shedding Control to shed or reconnect facility loads to limit connected load within the station capacity.

c) Immediately when the power imported from the main falls below the Minimum Import Level open the incoming feeder circuit breaker. Note: This needs to occur within the time constraints of any low forward power or reverse power protection on the incoming feeders.

d) After a programmable delay (from 0 to 20 minutes, initially set at 5 minutes) to reach stable load, enable Capacity Control in order to operate the appropriate number of generating sets.

**Selecting Prime Mode When Mains Unavailable**
When Test mode is de-selected, and Prime mode is selected after mains has failed (resulting in the system being in a default Standby mode), the Station Controller shall sequentially:

a) Continue to run the generators

b) Withdraw the “LEG Run-On” signal from the PCMS to allow shut down of LEGs.

c) Operate in accordance with Prime mode.

**Station Standby Mode**
In this mode the station shall operate as a standby power station that provides power at times when the mains supply is not available.

Capacity control shall be used to operate the appropriate number of generating sets and load shedding control shall be used to regulate the load.

The presence of the mains supply will be detected using phase failure relays on each incoming feeder.

**Mains Failure (Black Start)**
In response to a mains failure being continuously present for a programmable time period (as directed by the NSP (default 10 seconds)) to allow for automatic reclosing in the mains network the station controller shall sequentially:

a) Open the connected feeder HV CB.

b) Issue a Call to Start to all available sets;

c) Open all HV ring main and Interconnector circuit breakers. Any Bus-ties shall remain closed.

d) Shed all LV load groups.

e) Initiate a “LEG Run-On” signal via the PCMS to ensure that the LEGS continue to operate after the CEPS is connected.
f) Wait till all available sets are connected.
g) Close the Interconnector HV CBs;
h) Enable Load Shedding Control, which will:
i) Sequentially close all feeder HV CBs,
j) Sequentially reconnect load groups
k) Allow the Load Shedding System to reach a stable state i.e. no load shedding operations for a programmable delay (from 1 to 10 minutes, initially set at 5 minutes) (not necessarily with all loads connected). Enable Capacity Control to operate the appropriate number of generator sets.

**Mains Return**
In response to mains being continuously available for a programmable period. (as directed by the NSP (0-30 minutes, default 10 minutes)) the Station Controller shall sequentially:
a) Synchronise to the mains and close incoming feeder circuit breaker.
b) Remove the “LEG Run-On” signal via the PCMS to allow the LEGS to shutdown
c) Disable Load Shedding Control, which will reconnect all loads. Reconnection of loads back to mains shall be done in a progressive manner to avoid large load steps to the NSP.
d) Remove the Call to Start and issue a Call to Stop to all running sets.
e) When each set stops remove its Call to Stop.

**CEPS Bus-tie**
Whilst the normal configuration of the CEPS is with the CEPS HV Bus-tie closed, the Station Controller shall monitor the status of the Bus-tie and adjust the station operation to suit.

The GCS shall operate to ensure that there cannot be two unsynchronised supplies connected to the system. In particular:
a) If the CEPS Bus-tie is open and a ISS/CEPS Interconnector cable is in service:
   – Enable only those generators that are connected on the CEPS bus to which the Interconnector is connected. The station controller shall be inhibited from issuing a Call to Start to the generators that are connected to the other CEPS bus however they will be able to operate in Manual mode. The disabled generators shall indicate that they are “Not Available in Auto” on their Generator Control Panels when they are in Duty or Standby mode.
b) If the Bus-tie is open and the ISS/CEPS Interconnector cable is out of service:
   – Enable only those generators that are connected CEPS bus to which has the highest Available Capacity. The Station Controller shall be inhibited from issuing a Call to Start to the generators that are connected to the other CEPS bus however they will be able to operate in Manual mode. The disabled generators shall indicate that they are “Not Available in Auto” on their Generator Control Panels when they are in Duty or Standby mode.
Selecting Test Mode Under Mains Failure
When Standby mode is de-selected and Test mode is selected when the CEPS is operating in response to a Mains Failure, the Station Controller sequentially:

a) Remain in standby mode until mains supply is continuously restored for the mains return time period.
b) Carry out all sequences as documented under Test mode except that some sets will already be running.

Selecting Prime Mode Under Mains Failure
When Standby mode is de-selected and Prime mode is selected when the CEPS is operating in response to a Mains Failure, the Station Controller shall:

a) Withdraw the “LEG Run-On” signal from the PCMS to allow the LEGs to shutdown.

Station CPS Prime Mode
Operate as required for prime mode and in particular ignore any restoration of mains supply.

In this mode the station operates as a prime power station islanded from mains supply.

Capacity Control shall be used to operate the appropriate number of generator sets and Load Shedding Control shall be used to regulate the load.

Starting Prime Mode
Upon prime mode being selected the Station Controller shall sequentially:

a) Issue a Call to Start to all Available sets. (The Station Controller programming shall allow for starting of all sets including those marked as future but shall only affect those installed initially). In response the individual Generator Controllers shall start the sets synchronise with the mains, close the associated generator HV CB, and remain unloaded until all available sets are connected.
b) Progressively load all generators to assume the Base load while maintaining the Minimum Import Level.
c) Enable Load Shedding Control keep the demand within the capacity of the CEPS.
d) Open the incoming CB to island the base.
e) After a programmable delay (from 0 to 10 minutes, initially set at 5 minutes) to reach stable load, enable Capacity Control to operate the appropriate number of generator sets.

CEPS Bus-tie
Whilst the normal configuration of the CEPS is with the CEPS HV Bus-tie closed, the Station Controller shall monitor the status of the Bus-tie and adjust the station operation to suit.

The GCS shall operate to ensure that there cannot be two unsynchronised supplies connected to the system. In particular:

a) If the CEPS Bus-tie is open and a ISS/CEPS Interconnector cable is in service:
   – Enable only those generators that are connected CEPS bus to which the Interconnector is connected. The station controller shall be inhibited from issuing a
Call to Start the generators that are connected to the other CEPS bus however they will be able to operate in Manual mode. The disabled generators shall indicate that they are “Not Available in Auto” on their Generator Control Panels when they are in Duty or Standby mode.

b) If the Bus-tie is open and the ISS/CEPS Interconnector cable is out of service:
   – Enable only those generators that are connected CEPS bus to which has the highest Available Capacity. The Station Controller shall be inhibited from issuing a Call to Start the generators that are connected to the other CEPS bus however they will be able to operate in Manual mode. The disabled generators shall indicate that they are “Not Available in Auto” on their Generator Control Panels when they are in Duty or Standby mode.

**Selecting Standby Mode When Mains Available**

If Prime mode is de-selected and Standby mode is selected when the NSP supply is available, the Station Controller shall sequentially:

a) Synchronise CEPS with the NSP mains across the appropriate HV incoming circuit breaker depending upon which supply was in use when Prime mode was selected.

b) Close the incoming circuit breaker.

c) Disable Load Shedding Control, which will reconnect all loads. Reconnection of loads back to mains shall be done in a progressive manner to avoid large load steps to the NSP.

d) Disable Capacity Control.

e) Remove the Call to Start and issue a Call to Stop to all running sets.

f) When each set stops remove its Call to Stop.

**Selecting Standby Mode When Mains Unavailable**

When Prime mode is de-selected and Standby mode is selected when the NSP mains has failed, the Station Controller shall sequentially:

a) Continue to supply the Base load using capacity control to operate the appropriate number of generating sets.

b) Issue a “LEG Run-On” signal to the PCMS to cause the LEGs to start and continue to run.

**Selecting Test Mode When Mains Available**

When Prime mode is de-selected and Test mode is selected, when the NSP mains is available, the Station Controller shall sequentially:

Synchronise with mains across the appropriate incoming circuit breaker.

a) Close the incoming circuit breaker.

b) Disable Load Shedding Control, which will reconnect all loads.

c) Disable Capacity Control.

d) Operate as required under Test mode.
Selecting Test Mode When Mains Unavailable
When Prime mode is de-selected and Test mode is selected, whilst the NSP mains has failed, the Station Controller shall sequentially:

(a) Issue the “LEG Run-On” signal to the PCMS to cause the LEGS to start and continue to run.

(b) Once the NSP mains returns and remains stable for a predetermined period as directed by the NSP (a programmable time period between 0 to 30 minutes, default 5 minutes), synchronise CEPS with the NSP mains across applicable incoming circuit breaker.

(c) Close the incoming Circuit breaker.

(d) Remove the “LEG Run-On” signal via the PCMS to allow the LEGS to shutdown.

(e) Disable Load Shedding Control, which will reconnect all loads.

(f) Disable Capacity Control

(g) Operate as required under Test mode.

Station Peak Lopping Mode
The GCS shall include a Peak Lopping Mode that enables the generator to be used to supplement the mains supply. The Peak Lopping mode will be enabled whenever the GCS is in Test or Standby Mode.

Peak Lopping Mode can only reliably operate when the HV distribution system is in its normal “closed up” configuration. If the HV system is split as a result of the CEPS Bus-tie being open being out of service the GCS cannot easily identify how its actions will affect the power flows in the HV system or the incoming feeders. In order to prevent undue complications in the control system Peak Lopping Mode shall be disabled whenever the CEPS Bus-tie is open or an Interconnector cable is out of service.

The peak lopping mode shall be triggered by the following events:

(a) Base Demand Limit: This acts to prevent the Base demand exceeding a defined MW or MVA setpoint. This setpoint is defined from either:
   - A thumbwheel switch or similar, within the Station Control Panel, or
   - A 4-20mA signal from the Energy Management System (EMS).

   The selection shall be via a Off/MW Local/MVA Local/MW EMS/MVA EMS rotary switch within the Station Control Panel.

(b) Feeder Demand Limit: This acts to prevent the load on any incoming feeder exceeding the capacity of that feeder and acts independently of the Base Demand Limit.

Upon either Demand Limit being exceeded the generators shall automatically start, synchronise and connect as follows:

(a) The instantaneous load shall be continuously monitored and a first order filter with a time period of 10 minutes applied to calculate a thermal load. When this thermal load exceeds one of the active setpoints the system shall determine how many generators are necessary to keep the demand within the specified limits.
b) The required number of duty generating sets shall be issued with a Call to Start, causing them to start, synchronise and connect to the mains.

c) The load on the generator/s will be controlled to maintain the thermal load on the mains at less than the programmed Peak level and also maintain the minimum recommended load on the generator/s. The GCS shall also maintain the Minimum Import Level on all feeders.

d) Enable Capacity Control to operate the appropriate number of generating sets.

e) When the thermal load of the Base drops below the relevant setpoint (less the Spinning Reserve as hysteresis to ensure stability) for a predetermined period, the last generating set shall be issued with a Call to Stop.

Example

For:

- Feeder Demand Limit = 6.0MVA
- Spinning Reserve = 0.5MVA
- Genset Capacity = 1.0MVA
- Genset Minimum Load = 0.3MVA

f) When the 10 minute thermal demand rises above 6.0MVA one set will receive a Call to Start.

g) The set will synchronise and connect. It will then ramp up until it operates at 0.3MVA. This will reduce the feeder load to 5.7MVA.

h) If the Base load increases to above 6.3MVA the set will take on more load to ensure the feeder load stays below 6.0MVA.

i) If the Base load increases above 7.0MVA a second set will start and once connect will share load with the existing set.

j) If the load then falls below 6.5MVA the second set will disconnect and stop

k) If the load falls below 5.5MVA the last set will disconnect and stop.

**Station Capacity Control**

The Station Controller shall determine the amount of generation capacity required to meet the System Load and Spinning Reserve. It shall use this information to schedule on the required number of generating sets.

Should the HV ring mains or load groups be shed as a result of a lack of Available Capacity the system shall seek to run additional sets to provide adequate capacity.

When determining which sets to schedule on the Station Controller shall first issue a Call to Start to those Available sets that are in Duty mode and then those in Standby mode. If all Available sets are running, and additional capacity is still required, the Station Controller shall issue a Call to Start to those sets that are not Available due to a Warning, however these sets shall be used as a last resort only.
Should a set become not Available while running the Station Controller shall immediately issue a Call to Start to a replacement set, if available, and transfer the load to this new set. Once the new set has assumed the load the Station Controller shall then issue a Call to Stop to the set that is no longer Available. If no replacement set is Available then the not Available set shall continue to receive a Call to Start.

The running sets shall share both real and reactive power in proportion to the set capacities. Set capacity shall be determined from a value stored in the relevant Generator Controller, not in the Station Controller. This figure shall be stored in a single location in the controller program, and shall be initially set at the prime rating of the set appropriately de-rated for the site.

In order to prevent unnecessary starting and stopping of sets the system shall provide hysteresis between starting and stopping of sets based on the Remaining Capacity of the CEPS and the time at that load. This can be done as a percentage of the On-line Capacity such that trigger points at say 80%, 90% and 100% of capacity as well as having a predictive load ramp function. At 100% load it is expected that an immediate signal would be sent to run available engines. The same procedure would be adopted for reductions in load to shut down generator sets. It is preferred that some of the time delays are incorporated in the Generator Controller thus permitting the “Call to Start” and “Call to Stop” indicators to represent their true function.

When Capacity Control is disabled the GCS shall issue a Call to Start to all Available sets. This will cause these sets to run and connect.

**Station Load Shedding Control**

**Load Shedding Devices**

Load-shed devices are provided on the LV side of the distribution substations or at the facilities that enable those facilities to be disconnected from the electrical system. These load-shed devices are under the control of the Power Control and Monitoring System (PCMS) that runs on the Defence Engineering Services Network (DESN). Each load-shed device is allocated to one of ten load groups within the PCMS and can be individually controlled from the DESN Terminal. The PCMS disconnects and connects load groups on request by the Station Controller. These requests are passed using hardwired lines that connect the two.

Load shedding, at a more course level, can also be accomplished by operating of the HV circuit breakers that control the HV ring mains. These HV circuit breakers are under the direct control of the Station Controller.

**Load Shedding Mode Selection**

Each load group shall have a single, rotary, “Manual/Auto” selector switch located on the front of the Station Control Panel that determines the operating mode of that load group.

The control switches, and indicators showing the status of each load group are also located on the front of the Station Control Panel, directly below HV system mimic.
Changing between modes shall be bump less.

**Load Shedding Manual Mode**
In manual mode the operation of the load group shall be from a rotary, centre spring return, “Shed/Connect”, control switch.

**Load Shedding Auto Mode**
In auto mode the operation of the load group shall be from the Station Controller.

The following parameters determine the operation of the load shedding system:

a) Spinning Reserve – see Definitions.
b) Load Shedding Hysteresis – see Definitions.
c) On-line Capacity – see Definitions.
d) Available Capacity – see Definitions.
e) System Load – see Definitions.
f) System frequency

Three (3) events shall initiate an automatic disconnection of load. These events shall be based on the following parameters (with adjustment of trigger levels and ring main priorities programmed into the Station Controller at a single location to allow easy alteration):

a) **System Load exceeds Available Capacity:** Under this event either the power station is overloaded or there is inadequate reserve. Load must be disconnected to restore the Spinning Reserve. In most cases this is a relatively minor overload that can be corrected by minor load shedding.

b) **Set failure:** A set has failed and as a result there is likely to be a shortage of capacity. As each set has a significant capacity the shortage in capacity is likely to be large and need more extensive load shedding.

c) **System Frequency:** and Time at this Frequency: Should the system frequency fall then there has been a significant failure event and the stability of the entire system is at risk. In order to prevent collapse of the system and the need for manual re-start, gross load shedding is necessary to remove bulk load from the system as quickly as possible.

The load-shed strategy shall be as follows:

**Table 27.1 Load Shed Strategy**

<table>
<thead>
<tr>
<th>Event</th>
<th>Event Trigger</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>System Load exceeds On-line Capacity for more than 2 seconds</td>
<td>Shed one load group immediately then the remained, in priority order, at 2-second intervals until the situation is corrected.</td>
</tr>
<tr>
<td>1b</td>
<td>System Load exceeds Available Capacity for more than 120 seconds</td>
<td>Shed one load group immediately then the remained, in priority order, at 2-second intervals until the situation is corrected.</td>
</tr>
<tr>
<td>2</td>
<td>Set failure</td>
<td>Reducing the Available Capacity by the capacity of the set that has failed. Shed the next two load groups immediately then monitor capacity as per Event 1. Number of load groups to be shed shall be site adjustable. Start another set, if available, to</td>
</tr>
</tbody>
</table>
The timing of the load shedding actions shall be trimmed during commissioning to ensure system stability. When the CEPS is supplying the Base the GCS shall automatically reinstate loads as capacity becomes available. The GCS shall continue to connect loads provided:

a) System frequency is above 49 Hz for the last 15 seconds, and
b) System Load is lower than the Available Capacity less the Load Shedding Hysteresis

The connection of loads shall proceed as follows:

a) Connect the HV ring mains, one end at a time, in priority order, at 4-second intervals.
b) Once all ring mains are connected and the system has been stable for 6 seconds it shall start connecting load groups in priority order at 4-second intervals until the connected load exceeds 80% of the Remaining Capacity. Then loads shall be reconnected at 20-second intervals.

The connection of any HV ring main or load group shall be reversed if either of the following conditions occurs:

a) System Load exceeds the On-Line Capacity for more than 2 seconds, or
b) System Load exceeds the Available Capacity for more than 120 seconds.

The GCS shall measure System Load before a HV ring main or load group is connected and also the System Load at the time of disconnection. From these values it shall calculate the incremental load associated with that HV ring main or load group. Before the GCS attempts to reconnect this HV ring main or load group it needs to ensure that there is adequate capacity for this increased load. It shall do this by changing the Load Shed Hysteresis to equal the size of the incremental load with an additional 10% margin to avoid any possibility of hunting. Thus when spare capacity exceeding the new load shed hysteresis is available the GCS will again try to reconnect the load.

The Load Shed Hysteresis shall be reset to its default value when:

a) The load reconnection is successful, or
b) The relevant load group is switched to Manual mode at the Load Shedding Panel or the HV ring is switched to Manual mode at the HV mimic.

When Load Shedding Control is disabled the GCS shall progressively reconnect all remaining loads, as above, until the system is fully connected. Load Shedding Control shall remain active until the last load group is reconnected. In particular it shall ensure that the feeders do not exceed their Feeder Demand Limits as the loads are restored.
Detection of Mains Failure while in Parallel with Mains
The control system shall detect a mains failure while the generators are running in parallel with the mains and immediately open (non-latching) the incoming HV CB to isolate the Base. The system shall then operate as for a mains failure.

The following means shall be used to detect a mains failure:

a) Reverse power (when the installation is not permitted to export power)

b) Vector shift or Rate of Change of Frequency, particularly when the installation is running at relatively high import or export levels.

c) Power flow at the incomer dropping to zero: The control system should not operate at zero power transfer across the incomer HV CB for extended period if the CB is closed. If the power flow remains near zero for an extended period then a power failure has occurred.

Setting of Control Parameters

Spinning Reserve
The spinning reserve is set using a 3½ digit thumb wheel switch or other approved device on the front of the GCS Station Controller cabinet and will initially be set to accommodate the largest single load that can be expected to be started (default 300 kW).

Load Shedding Hysteresis
Its default value is set using a 3½-digit thumb wheel switch or other approved device within the GCS Station Controller cabinet (default 200 kW).

Feeder Demand Limit
The values shall be set using a 3½ digit thumb wheel switch for each incoming feeder or other approved device within the GCS Station Controller cabinet and be settable up to the maximum expected long term feeder load (in MVA). It is recommended that initially the Feeder Demand Limit be set to the Authorised Feeder Demand defined in any connection agreement with the NSP.

Final Values
The final values of the control parameters shall be determined during commissioning to ensure system stability.

27.5.6 Controller Requirements

General and Hardware
The general topology of the generator control system shall include the use of a Generator Controller in each of the Generator Control Panels and a Station Controller in the Station Control Panel within the CEPS Control Room. Remote controllers or I/O modules shall be located at any other PSSs.

Inclusive in the Controllers shall be watchdog timer, real time clock/calendar and all other facilities to ensure successful operation.
Input and Outputs
The Design shall maintain a level of not less than 20% spare I/O within each Controller.

Software

Standard
All custom software to be in accordance with AS 4168.3 (IEC 1131.1 - 1993) Programmable controller Part 3 Programming Languages Structure.

Nomenclature
The Design shall coordinate with other Trades to ensure that I/O descriptions, tags, displays, software annotation and labelling are consistent generally and the same for any individual signal or function throughout the establishment.

Functional Description
A copy of the functional description shall be provided in the operations and maintenance manuals.

Licensing
Provide a full version, licensed copy of all software necessary to reprogram or interrogate each Controller, registered in the name of the Principal.

At least 1 (one) copy of all appropriate custom Controller software developed by the Contractor shall remain with the Principal.

Any software patches issued within the defects and liability period that pertain to the brand and version of software utilised within the GCS system shall be supplied free of charge from the Contractor.

Diagnostic Functions
The Controller CPU shall constantly perform self-checks to identify any memory, system-program or user-program faults. The power supply, battery, I/O bus and cycle time shall also be monitored.

Self Test
The Controller shall be provided with a self-test facility that can be activated by service personnel only. This facility shall test the correct operation of the major elements of the Controller.

Power Supply
The Controller shall be suitable for operation from a nominal 24 V DC power supply.

27.5.7 Attempering Control Systems

General
Attempering systems use water sprays to reduce exhaust gas temperatures from each generator set. The purpose of the cooling sprays is to reduce the exhaust gas temperatures expelled into the atmosphere so as to reduce the heat signature of the CEPS installation.
Provide an On/Off switch on the Station Control Panel cabinet to enable or disable the Attempering System.

**Control Philosophy**
Modulate the water flow in the Attempering System in response to exhaust air temperature. The control algorithm shall ensure that the maximum exhaust air temperature reduction is achieved and at the same time the risk of fogging external to the building and wastewater discharge are minimised. To achieve this compensate for ambient air conditions.

**27.5.8 Communications**
Communications equipment shall generally be connected to the local batteries that supply the GCS. Where this is not possible, the equipment shall be connected to a guaranteed supply from either a standalone UPS with at least the same standby duration as the GCS battery system or from an inverter off the GCS batteries. The GCS network shall be completely separate to and segregated from any other network.